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Developmental Changes in Cognition: An Evaluation of a Philosophy for Children Program

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THESIS ACCEPTANCE

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CHAPTER I

INTRODUCTION, TRAINING STUDIES, INDIVIDUAL DIFFERENCES AND HYPOTHESES

Introduction

The formal operational stage seems to differ considerably from earlier Piagetian stages. The first three Piagetian cognitive stages seem to develop fully in all individuals, unless there is a major cultural difference or a major psychopathology (Bruner, 1966). In contrast, there is disagreement in the literature as to whether formal operational reasoning fully develops in all normal individuals. Both Dulit (1972) and Tomlinson-Keasey (1972) found evidence that some normal individuals never attain formal operational reasoning. Others however (Jackson, 1965; Lovell, 1961) agree with Piaget (Inhelder and Piaget, 1958) that the emergence of formal operational reasoning occurs invariably between 11 and 12 years of age. The uncertainty about the nature or age of emergence of formal operations is clear. It may be due partly to the variability in the method of assessment of formal operational reasoning; different formal tasks may measure different areas of formal reasoning competence. Berzonsky, Weiner and Raphael (1975) have thus suggested that formal reasoning is a potential competency that is developed in each area as a function of specific situational variables or specific environmental experiences. Even Piaget (1972) has recently admitted that the acquisition of formal thinking may depend in part on particular educational and cultural factors.

Although every investigator agrees that the acquisition of formal operational reasoning is dependent upon both maturation and experience, there remains disagreement as to the degree of maturation or kind of experience necessary for the emergence of formal operational reasoning (Kingsley & Hall, 1967; Siegler, Note 1; Webb, Note 2). The amount and type of experience a child needs to make the transition from one stage to another in a given area is thus an important issue associated with Piaget's theory of cognitive development. Inhelder and Piaget (1958) state that "A particular social environment remains indispensable for the realization of...possibilities and impossibilities at a given stage. It follows that their realization can be accelerated or retarded as a function of cultural and educational conditions" (p. 337). Piaget emphasized, however, that the order of appearance of the four stages of cognitive development will remain invariant even in differing cultures. The cross-cultural findings of Goodnow and Bethon (1966) and Peluffo (1967) support this claim.

Piaget recognizes that the environment influences the development of logical thought, but he does not seem to concern himself with individual differences which may account for the difference in onset of the developmental stages. Stating that the environment influences an outcome is meaningless, unless particular experiential factors can be isolated. These experiential factors include but are not limited to the role of culture, language, personality, and individual experiences. Researchers have traditionally utilized either of two different approaches in attempting to elucidate the obscure nature of these experiential factors. The majority of studies of formal operations prior to 1970 have employed a factor analytic or correlational approach. There has however been a substantial increase in the number of experimental or training studies investigating formal operations since 1970. Both of these research strategies are useful evaluative means of explaining the change from concrete to formal operations. No previous published research has employed both of these methods simultaneously. Training studies could be made more effective and explanatory if individual differences were isolated or if correlates of formal reasoning were further explored.

The effects of training on conservation tasks has been studied more than the effects of training on other Piagetian tasks. The majority of conservation intervention studies before 1965 were not successful in training for conservation tasks (Smedlund, 1961; Wohlwill & Lowe, 1962). The failure of these early intervention studies prompted Flavell (1963) to conclude that Piagetian concepts have so far proved inordinately difficult to stamp in, whatever the training procedure used. However, recent studies (Brainerd, 1974; Gelman, 1969; Wallach, Wall & Anderson, 1967) have shown significant improvement in conservation trained subjects. A reason for the turnabout in results is that earlier studies tried to teach conservation directly, whereas later studies taught logical prerequisites of conservation. Goldschmid (1971) states that "in contrast to the early experiments...the use of such concepts as reversibility, compensation, and the emphasis on relevant perceptual cues have led to significant improvements in cognitive functioning in trained subjects" (p. 104). Piaget however seems to deemphasize the acceleration or training studies and characterizes them as the "American question." Yet, the overwhelming majority of these studies were not carried out with the primary purpose of acceleration per se, but rather to pinpoint the specific experiential prerequisites for acquiring a given schema (Goldschmid, 1971).

Training or intervention studies are important, in that they may tell us what the optimal environment is for maximal learning at each cognitive level. With a better understanding of changes in cognitive development, it may be possible to facilitate the cognitive growth of those not functioning up to their mental potential. But for this understanding to occur, we must be sure that the changes resulting from the training phase are permanent and not the product of pseudo-training. It is clear that the effectiveness of intervention is dependent on the nature of the intervention, type of problem, and stage of cognitive development. Siegler (Note 1) found that type of training accounted for 47% of the total variability in his data. Flavell and Wohlwill (1969) have shown that transitional subjects are especially susceptible to situational variables. Therefore, it is important to examine the strategy in both evaluating intervention studies and in performing this type of study.

Training Studies

A number of investigators have found significant results in training for formal operational reasoning. Tomlinson-Keasey (1972) using five Inhelder and Piaget (1958) tasks in testing and training for formal operational reasoning found significant increases in three groups of females. The pendulum, balance, and flexibility problems were used for the pretest, the training session, and the immediate posttest. A one week delayed posttest consisted of a modified flexibility problem, a chemical problem, and an inclined plane problem. "The training session incorporated the following principles: (a) training should be tailored to the individual, (b) subjects should be actively involved, (c) subjects should be placed in conflict, and (d) training should proceed from simple to more complex concepts" (p. 364). The posttest required the subjects to teach the concept to a confederate of the experimenter. The experimental and control groups did not differ on either of the chemical or inclined plane problems, although differences on the flexibility problems were durable. These results suggest that training was highly specific for one particular task.

The findings of Kuhn and Angelev (1976) are consistent with those of Tomlinson-Keasey. Kuhn and Angelev utilized a 15 week intervention period during which subjects operated structures designed to be parallel to the Inhelder tasks (pendulum and chemicals) but superficially dissimilar. The pendulum, chemical, and a set of specially designed verbal problems were given for both pretests and posttests. Significant increases within the transitional stage for both the pendulum and chemical problems were monotonically related to the amount of intervention. The intervention had no effect on the verbal problems. The authors attribute this to two possible causes: (1) The application of formal operational reasoning was the most difficult for the verbal problems. (2) The "demonstration" type of training (necessary for the verbal problems) is not as effective as the "exposure" type of training (used in the chemical and pendulum problems).

Fischbein, Pampu, and Minzat (1970) investigated the effect of a step-by-step teaching strategy using generative "tree diagrams" on the ability of 10, 12, and 14 year olds to handle permutations and arrangements. Fischbein has focused much of his research on combinatory ability in children. In using combinatorial logic the child can generate all the permutations as well as combinations of a given set. The systematic and specific intervention involved having the subject draw a step-by-step diagram, after which he had to interpret the diagram and write down the groups obtained. When the subject understood the diagram method, he was asked to get the same result using simple computation. The subject was coached if he failed to pass directly from the diagram to the computation. The results from their investigation showed that combinatory ability improved with age, with a plateau at age 12 (no significant differences between age 12 and 14). The results also showed that 10 year old subjects learned the appropriate procedure for permutations with the use of the "tree diagrams", but not without them.

A few studies have attempted to train persons using this type of intervention strategy. Barratt (1975) successfully produced significant improvements in performance on combinatorial tasks with a "programmed discovery" method of intervention. The intervention incorporated a booklet that presented a series of combinatorial problems, from simple to difficult, and provided spaces for subjects to record solutions. On the page following each problem, a correct and systematic solution was given. The increases in combinatorial skill showed a significant main effect for age in 12 to 14 year old subjects. Barratt does not imply that "formal operational reasoning was developed in preformal students but rather that its performance was facilitated with subjects who had already acquired the necessary competence or structures in some preliminary or latent form" (p. 703).

Siegler and Liebert (1975) were successful at inducing combinatorial reasoning in 10 and 13 year old subjects. In their study subjects were assigned to one of three conditions: conceptual framework plus analog problems, conceptual framework alone, or control. Subjects exposed to the conceptual framework were taught three principles: (1) division of problems into factors (anything you believe will have an effect on something else), (2) division of factors into levels (ways that factors can be used), and (3) use of the concepts of factors and levels in producing tree diagrams. Analog training consisted of asking the children to list the factors and levels of a problem and to draw a tree diagram that would represent all possible solutions. The conceptual framework alone group were asked to twice copy a tree diagram they had been shown. Siegler and Liebert found significant differences in the proportion of children in each group who generated all possible combinations of colutions to a problem. Seventy percent of 10 year olds in the conceptual framework with analogs group were able to produce all possible combinations, whereas their peers in the other two groups were not able to generate these combinations. All of the 13 year olds in the conceptual framework with analogs group, 50% of the conceptual framework alone group, and 10% of the control group were able to produce all possible combinations. Subjects were also given the option of keeping records of their combinations. The conceptual framework with analogs group used written records more so than either of the other two groups. Siegler and Liebert suggest that the differential reaction of the conceptual framework with analogs group was due to differential ability of 10 and 13 year olds to anticipate the possible complexity of the problem.

Ross, Hubbell, Ross, and Thompson (1976) compared three different formal operational training strategies: (1) cognitive conflict, (2) concept formation, and (3) didactic training. They found a significant ($p < .01$) effect of didactic training on the chemicals task and a nonsignificant effect for the cognitive conflict and concept formation strategies. In didactic training the subject was taught the dissociation schema rule that "if you want to prove that a specific factor causes something, you must hold all other factors constant and vary only that one factor." The subject was then shown how the rule was applied to several different problems, including the formal operational flexibility of rods task. Ross et al. suggest that the cognitive conflict and concept formation training provided "noisy" background stimuli for the concept or rule to be learned. Didactic training differs in that the instruction presents a greater signal to noice ratio so that the concept can be learned more efficiently.

Summary of Training Studies

There is no evidence that the above training studies have any lasting effects, and no evidence that getting to the subsequent stage faster is better. The experimental studies to accelerate the acquisition of formal operations have thus had only limited and transient success. The training studies did demonstrate that certain experiences were required to produce the transition from concrete to formal operations. The results of the above studies are limited since all the training studies were concerned with specific training for a particular task, with the training tied very closely to the assessment task. One can complain that the above investigators were only teaching students a method of tackling a particular task (that subjects were taught certain responses rather than gaining an understanding of the concept). The Tomlinson-Keasey study supports this view since there was no transfer to either of the other two tasks. Another criticism of the above studies is that the training programs are not readily available in the average environment. It is also not practical to administer the above interventions to a large number of subjects.

In summary, it is clear that children can benefit from training on a particular task but these studies do not tell us what the role of the natural environment is. The nature of formal operations make the effects of training on formal operational tasks as difficult to decipher, if not more so, than the effects of training on conservation tasks. This difficulty, as mentioned before, may be due to the variation in method of assessment of formal operations, to the type of interventions used, and to the lack of a large body of comparable studies with which to evaluate formal operational development.

Another approach to training studies is to make the training very general and to test the effects of the general training on the performance of several specific tasks. Siegler and Liebert and Ross et al. both attempted to do this to some extent, but their training was still specific to a particular type of problem. Training at an even more general level in logical reasoning and critical thinking should facilitate formal operational reasoning in all areas, since logic constitutes, in Piagetian terms, the very basis for formal operational reasoning. If formal operational thinking is a truly general form of reasoning, then its development should be a function of this kind of training rather than of training in a specific task. It is important therefore that an intervention program be designed to assess the effect of this type of general training. Such a study may provide us with the information necessary to understand the transition from the concrete to the formal operational level, and with this information it may be possible to facilitate cognitive growth by developing or advancing substructures of the subsequent stage.

Individual Differences and Hypotheses

Another issue in the development of formal operations is individual differences. The Pascual-Leone theory of cognitive development attempts to integrate individual differences into a theory of cognitive development (Pascual-Leone, 1970). Pascual-Leone has conceptualized Piaget's cognitive-developmental variable as a quantitive construct, the central processor M. The measure of M is the person's maximum mental effort or the maximum number of schemes his psychological system is capable of activating at any one time. The M measure is a quantitative characteristic of each developmental stage and is assumed to grow in an all-or-none manner as a function of age. In investigating individual differences in cognitive development, Pascual-Leone has concentrated primarily on the dimension of field independence-dependence. According to Case (1974) field independent persons are assumed to be habitually high M-processors, who assign a higher weight to the task instructions than to perceptual cues, in situations where these two sets of cues suggest conflicting schemes. Field dependent individuals are assumed to be habitually low M-processors who assign higher weight to perceptual cues than to cues provided by the task instructions in such conflicting situations. Neimark (1975) in a four year longitudinal study of formal operational thought, found evidence to support Pascual-Leone's (1970) theoretical proposition that field independence is a relevant factor in the development of formal operational reasoning. Using the Embedded Figures Test (EFT) to assess field independence-dependence, she found that both EFT measures (number solved in less than 180 seconds, and total time) correlate significantly with the combination, permutation, and problem solving tasks but not with the correlations problem.

Case (1974) in a concrete operational intervention study also presented evidence to support the Pascual-Leone theory of cognitive development. Three groups of subjects were selected for the pretest phase. Group 1 included 8 year old subjects who were field independent and cognitively normal by Piagetian standards. Group 2 were 6 year old subjects who were field independent and cognitively normal by Piagetian standards. Group 3 were 8 year old subjects who were field dependent and cognitively normal by Piagetian standards. The measures used to assess cognitive development were conservation of substance and of weight. The measure used to assess field independence was the WISC blocks.

In the training phase, "subjects were led through the set of operations necessary for understanding the impossibilities of being 'sure' about what had produced the result; then by presenting them with a variety of similar situations in which...they could convert this newly acquired insight into a well practiced routine for setting up a fair proof or for checking the adequacy of someone else's proof" (p. 561).

The initial purpose of the posttesting phase was to determine whether subjects could transfer what they had learned to new situations. The second purpose was to determine whether learning was durable. The third purpose was to determine whether field independent 8 year olds possess combinatorial abilities. Each subject was tested individually on a test called Bending Rods and on a formally similar test called Spinning Wheels. Bending Rods is an adapted version of a task originally designed by Inhelder and Piaget (1958). In the Spinning Wheels test the dependent variable is the relative length of time two marbles remain on a spinning wheel.

Case found that the proportion of field independent 8 year olds who passed both the immediate posttest and the delayed posttest was significantly higher than the proportion of field dependent 8 year olds who passed. Only one of the ten field independent 6 year olds passed either of the immediate posttests. There were no significant differences between the instructed and uninstructed groups in the mean number of combinations generated. Case concludes that certain formal problems can be solved or that a formal substructure can be acquired at the beginning of the concrete operational stage.

Other indices of individual differences that have been related to formal operational thinking include: analogical reasoning (Lunzer, 1965), productive thinking (Saarni, 1973), and the Pupil Personality Evaluation Form (Cloutier and Goldschmid, 1976). Lunzer has suggested that reasoning in terms of verbal analogies is related to an understanding of proportional relationships and thus requires formal reasoning to solve. He found that concrete operational children did not have the cognitive ability to reason analogically but that formal operational children, those with an understanding of the concept of proportionally, could reason analogically. Saarni found that Piagetian developmental level significantly predicted productive thinking performance. She suggests that formal operational individuals are more competent problem solvers on the productive thinking problems than those who are classified as concrete operational. Cloutier and Goldschmid investigated the relationship between formal operations and personality variables. They found that the formal operational child could be characterized as being: (1) active and quick to respond, (2) able to develop a systematic method of reasoning, (3) able to produce original ideas, (4) low on self-confidence, (5) able to initiate activities when left along, and (6) requiring less discipline than the average child in the classroom.

The purpose of the present study is then twofold; first to evaluate the effectiveness of general training in logical reasoning and critical thinking on promoting formal operations, and second to evaluate further the effects of individual differences in field independence-dependence, productive thinking, personal variable, and analogies on formal operational development.

The following hypotheses were tested:

1. Experimental subjects will score significantly higher on the posttest formal operational tasks than control subjects.
2. Experimental subjects will score significantly higher on the posttest field independence, productive thinking, and analogies problems than control subjects.

3. Field independence, productive thinking and analogies will correlate highly with formal operational reasoning.
4. Since combinatorial ability is required to solve the verbal analogies, experimental subjects will score significantly higher on the verbal section of the analogies test than control subjects.

CHAPTER II

METHOD, MEASURES, PROCEDURE, INTERVENTION

Method

Subjects

The sample consisted of a subset of those children involved in the "Philosophy for Children" program, consisting of 56 subjects evenly divided (28 in the experimental group, 28 in the control group) between two fifth-sixth grade classrooms in two different schools. Subject participation was voluntary in this study. The experimental group of 9 fifth and 19 sixth grade students consisted of 12 females and 16 males. The control group of 10 fifth and 18 sixth grade students consisted of 14 females and 14 males. Table 1 summarizes the proportion of males vs. females and fifth grade vs. sixth grade subjects in each group. The two participating elementary schools serve an upper middle class neighborhood in Omaha, Nebraska. The general training intervention was applied to one of the classrooms while the other classroom, which was matched for IQ, age, sex, and social class, served as the control group.

Table 1

Proportion of Males vs Females and Fifth vs Sixth Grade Subjects in Each Group

	Experimental		Control	
Sex	Fifth	Sixth	Fifth	Sixth
Males	6	10	8	6
Females	3	9	2	12

The subjects had a mean IQ of 110 with a range of 81 to 141. No significant difference was found between the IQ's of the two groups ($F = .002$, $df = 2/53$, $p > .99$). All IQ's were determined by scores on the Otis Lennon Mental Ability Test obtained from school records.

The subjects had a mean chronological age of 11:7 years, which according to Piaget is the approximate age of emergence of formal operational reasoning, with a range of 10:2 to 12:6 years. There was no significant difference between the chronological ages of the two groups ($F = .689$, $df = 2/53$, $p > .511$).

Four of the original 28 experimental subjects did not complete the training intervention. The scores of these four subjects were thus not included in the evaluation of the intervention program, although their scores were used as part of the normative data.

Measures

Pretests

1. Group Embedded Figures Test. The Group Embedded Figures (GEFT) is a paper and pencil test which gives a direct measure of field independence-dependence by assessing an individual's ability to detect simple geometrical figures contained within much more complex figures.

2. Analogies. Lunzer (1965) suggests that verbal and numerical analogies require formal reasoning in the sense that their solution demands the apprehension of second order relations or relations between relations, and not merely first order relations. Previous research (Goldstein, 1962; Lunzer, 1965) has revealed a significant shift in ability to solve analogies at approximately 11 years of age. The Analogical

Reasoning Test developed by the experimenter consisted of two parts: a verbal section containing 20 items and a numerical section also containing 20 items (see Appendix A). The difficulty of the verbal items varied and required combinatorial ability to solve (e.g., TELEPHONE is to WIRE as RADIO-COPPER-PROGRAM-TUNE is to PROGRAM-WIRELESS-TELEVISION-SONG). The numerical items also varied as to the degree of difficulty (from items requiring simple addition or subtraction to items that involve logarithmic series).

The Analogical Reasoning Test was previously tested on a fifth grade class to determine the appropriate level of difficulty. The author has obtained a .91 test-retest reliability coefficient for the test using a separate sample of fifth and sixth grade students.

3. Productive thinking problem. A detective type mystery story "The Old Black House", developed by Covington, Crutchfield, and Davis (1966) was presented to subjects in booklet form. The child in reading "The Old Black House" must extract contradictory facts from their embedding context, construct hypotheses, and make inferences from his hypotheses as to how to resolve the discrepancies and solve the problem of the disappearance of the black house. The child must be able to distinguish between facts that are relevant to the solution and facts that are irrelevant to the solution. The success in perceiving and combining only the relevant facts would seem to indicate that the subject is using an analytic approach and would imply relative field independence. The field dependent subject using a global perception to solve the mystery would be hindered by irrelevant clues. It appears that both formal operational reasoning and relative field independence are necessary to solve this type of problem.

4. Digit permutation task. The procedure for the digit permutation task was similar to that of Neimark (1975). The instructions were modified so that the test could be administered in a group. The subjects were asked how many different license plate numbers could be obtained from three digits and from four digits. The series of three digit numbers were primarily for practice. The number of new productions (NP) and initial marks constant (IMC) were scored for the four digit series. IMC is the score of successive permutations on which the first or the first and second digits are maintained constant (maximum = 32). Neimark has shown that IMC correlates significantly (.68, .75) with strategy.

5. Chemical combination problem. This problem was selected because it is a well established combinatorial task. Five containers filled with colorless, odorless liquids were presented to the subject. The subject was asked to make the yellow color by mixing different combinations of the chemicals. The systematic method of evaluating the role of each of the five elements requires combinatorial reasoning, which is a formal operational process.

Posttests

1. Group Embedded Figures Test. The GEFT was identical to the pretest version.

2. Analogies. The analogy test was identical to the pretest version.

3. Productive thinking problem. A different version of the productive thinking problem, "The Missing Jewel", was administered. "The Missing Jewel" requires the child to combine various clues so that he

can arrive at the correct solution to the mystery of who store the jewel. As stated before, both formal operational reasoning and field independence are required to solve this type of problem.

4. Digit permutation task. The digit permutation task was identical to the pretest version.

5. Chemical combination problem. The chemicals task was modified to reduce the effects of the pretest. It was felt that if the task was not modified the child would have been able to recall the two element combination solution from the pretest as well as the role of the other elements and thus would have solved the chemicals problem without having had the opportunity to demonstrate his understanding of the combinatorial concept. The posttest task was identical to the pretest task except that water was substituted in place of the chemicals. However, the experimenter still demonstrated the procedure with the original chemicals used in the pretest task. The experiment was thus redesigned so that it would be possible to tap the same underlying concept without having the child immediately solve the problem.

6. Pendulum problem. The pendulum problem, included as a generalization measure, requires the subject to envision the variables he might think to be relevant: (1) the length of the string, (2) the weight of the objects attached to the string, (3) the height of the dropping point, and (4) the force of the push. He must then systematically exclude the three irrelevant variables by evaluating the effect of one variable at a time. The pendulum apparatus consisted of three different lengths of string (14 cm, 22 cm, 30 cm) and a set of four different weights (5 gr, 10 gr, 20 gr, 50 gr). The child was shown how the pendulum was constructed and was asked what made the pendulum swing faster or slower.

Descriptive measures

In addition to the IQ score and the scores obtained from the pretest and posttest tasks, two other test scores were available from the school records of the subjects, the vocabulary and comprehension section of the Gates-MacGinitie Reading Tests.

Teacher rating scale

The Pupil Personality Evaluation Form (PPEF) developed by Sutherland and Goldschmid (1974) was employed to assess the effects of personal variables. The instrument consists of a five point rating scale filled in by the teacher and is a measure of the teacher's perceptions of her pupil's personalities and classroom behavior. The authors of the instrument have obtained a test-retest reliability of .88 for the scale. The PPEF has been used by Cloutier and Goldschmid (1976) to investigate the realtionship between personal variables and formal reasoning. They found that children with more active patterns of behavior develop faster and master concepts earlier. The present study has further explored the scale.

Procedure

Administration of tests

The five pretest measures of reasoning were administered by the experimenter in the same predetermined order to both groups of students during the first two weeks of February, 1977. At the beginning of the initial testing session, it was explained to all subjects that the tests did not measure knowledge of a specific subject. The anonymity of the subject when the data were reported was also explained. The GEFT, Analogical Reasoning Test, productive thinking problems, and digit permutation task were administered as a group test. Each subject was tested individually for the chemical combination and pendulum problems. The PPEF's were distributed to the teachers during the second week of May, 1977. The experimenter stressed the anonymity of both the subject and teacher when the data were reported. The completed PPEF's were collected during the fourth week of May, 1977. The six posttests were administered in the same order as the pretests during the third and fourth week of May, 1977.

Intervention

The intervention program utilized public school teachers who participated in a 16 week inservice training program on teaching logic and reasoning to children using Matthew Lipman's novel "Harry Stottlemeier's Discovery" (1974). This novel has been designed to promote cognitive and affective development through a story about a group of children's discovery of the importance of logic and critical thinking in their discussions. Discovery and discussion techniques are used to relate the principles of logic to the student's own life. Three major goals of the program as outlined by Lipman and Sharp (1975) are: (1) improve reasoning ability including perceptual inferences, logical inferences, and inferences from evidence; (2) develop creativity in the form of increasing spontaneity, imaginativeness and inventiveness; and (3) personal development including self confidence, emotional maturity, general self understanding, and interpersonal relations.

A pilot study, using 11 year old subjects, showed an increase of 27 months in mental age at the end of a 9 week intervention program (Lipman, Note 3). The experimental group showed significant gains over the control group in the area of logic and logical reasoning ($p < .01$). The mental ages (as computed from four subtests of the California Test of Mental Maturity, 1963 Revision Long Form) of the experimental group and the control group were 167 months (13 years and 11 months) and 140 months (11 years and 8 months), respectively. Bierman (Note 4) conducted a follow up study two and a half years later of students who participated in Lipman's study. He compared reading achievement scores (on the reading subtest of the Iowa Test of Basic Skills) and found a significant superiority ($p < .01$) in the reading scores for the experimental group.

Another evaluation of a "Philosophy for Children" program conducted by Haas (Note 5) showed a significant ($p < .025$) increase in reading grade equivalent scores in one school district but not in another. Haas found no significant differences between experimental and control students for either the verbal or nonverbal measures of logical reasoning. She attributed the lack of significant results for the logical reasoning tests to the fact that teacher training was concurrent with the implementation of the program. She suggests that the teachers thus did not have adequate time to fully assimilate the materials themselves and therefore did not feel comfortable or competent in teaching the materials to their pupils.

The intervention phase was formally implemented during the first week of February, 1977 and continued for 15 weeks. For a complete description of the intervention program see Gillespie and Langan (Note 6).

CHAPTER III

RESULTS, FACTOR STRUCTURE, TEACHER RATING SCALE

Results

Scoring

The performance criteria for the operational level on the chemical and pendulum problems were based on that of Inhelder and Piaget (1958). The performance criteria for the permutation problem was based on Martorano's (1974) scoring procedure (See Appendix B for a complete description of the performance criteria). All subjects in the present study received scores at one of the Piagetian levels; (1) early concrete, (2) late concrete, (3) early formal, and (4) late formal, for the three problems. The scoring of the Analogical Reasoning Test and GEFT was based on the number of items answered correct. The number of correctly answered items were also scored for the verbal section of the Analogical Reasoning Test. The scoring system of "The Old Black House" and "The Missing Jewel" problems were based on Saarni (1973). Each subject's performance was scored in four different categories: (1) number of discrepant facts or relevant clues noticed, (2) number of correct analytic choices made in the feedback units, (3) number of ideas for solution, (4) score on the solution scale (1 represents no solution; 5 represents an accurate and quickly deduced solution). An independent trained judge scored a random sample of the protocols. Inter-rater reliability for both the pretest and posttest scores were; .86 for the chemicals task, .89 for the permutation task, and .96 for the productive thinking problems. A comparison of levels on the permutation and chemicals problems showed that 94 percent of the subjects scored at the same or adjacent level. Subjects scored predominantly at the early formal stage (level 3) on the permutation problem. Scores on the chemical problem were almost evenly divided between the late concrete (level 2) and the early formal stage (level 3). The mean score and standard deviations for each task are presented in Table 2. The interrelations between the pretest measures are presented in Table 3, and between the posttest measures in Table 4.

Design

The basic analyses for this experiment were done with a 2 x 2 x 2 factorial design of the posttest scores with the pretest scores as covariates. The factors represented were: Group (Experimental vs. Control); Grade (Fifth vs. Sixth); and Sex.

Pretest Performance

A multivariate analysis of variance of main effect of group for the nine pretest variables was not significant ($F = 1.63$, $df = 9.36$, $p > .14$). The univariate F's showed that the control group scored significantly higher on the permutation problem than the experimental group ($F = 5.22$, $df = 1.44$, $p < .03$). The eight other variables did not have significant univariate F's for main effect of group.

Posttest Performance

An analysis of covariance was performed for each posttest variable with the pretest score as the covariate using the Multivariate

Table 2

Mean Score and S.D. for Each
Pretest-Posttest Variable

	Pretest		Posttest	
Variable	X	S.D.	X	S.D.
GEFT	12.12	4.74	12.77	4.54
Analogies	27.35	7.04	29.60	6.28
Verbal Analogies	11.87	3.11	12.92	2.66
Number of Clues	2.08	1.28	1.19	.95
Feedback Units	2.71	.57	3.02	1.58
Number of Ideas	3.92	1.86	3.69	1.59
Solution Score	3.62	1.36	3.23	1.06
Vocabulary	55.77	17.81		
Comprehension	54.89	17.90		
Pendulum			3.23	.62
Chemicals	2.52	.51	2.78	.61
Permutation	2.91	.63	3.18	.69
Number of Productions	19.81	3.83	20.27	3.66
Initial Marks	18.02	9.54	19.81	9.12

Table 3

Correlation Matrix for Pretest Variables

Variable	GEFT	Analogies	Verbal Analogies	Number of Permutations	IMC	Permutation	Chemicals	Clues	Units	Ideas
Analogies	.57*									
Verbal Analogies	.44*	.79*								
Number of Productions	.46*	.45*	.28							
IMC	.42*	.39*	.26	.80*						
Permutation	.23	.30	.20	.55	.74*					
Chemicals	.52*	.25	.18	.17	.20	.15				
Clues	.17	.28	.12	.28	.12	-.04	.00			
Units	.26	.44*	.40*	.36*	.15	.03	-.01	.22		
Ideas	.03	-.08	.15	.19	.23	-.11	.02	.32*	-.30	
Solution	.42*	.47*	.39*	.34*	.21	.21	.18	-.20	.31	-.17

* p .01

Table 4

Correlation Matrix for Posttest Variables

Variable	GEFT	Analogies	Verbal Analogies	Number of Permutations	IMC	Permutation	Chemicals	Clues	Units	Ideas	Solution
Analogies	.49*	.79*									
Verbal Analogies	.59*	.44*									
Number of Permutations	.44*	.35*	.37*								
IMC	.31*	.35*	.34*	.79*							
Permutation	.18	.38*	.32*	.60*	.78*						
Chemicals	.20	.18	.28	.04	.12	.29					
Clues	.27	.16	.15	.26	.18	-.13	-.03				
Units	-.01	.31*	.19	.16	.03	.03	-.08	.10			
Ideas	.10	.22	.21	.20	.13	.14	.07	-.04	.18		
Solution	.17	.34*	.30	.21	.04	-.02	.08	.19	.62*	.00	
Pendulum	.10	.22	.18	.32*	.34*	.34*	.50*	-.04	.03	-.10	.21

* p .01

computer program. Table 5 presents the analysis of covariance for significant effects for all variables. The significant grade by sex interactions were derived from small sample sizes and thus need to be replicated. In general, the mean score for each variable increased from the pretest to the posttest. A multivariate analysis of variance of differences between groups for the nine posttest variables was significant ($F = 2.17$, $df = 9/36$, $p < .05$). A multivariate analysis of covariance for main effect of group, using the nine pretest scores as predictor variables was also significant ($F = 2.57$, $df = 13/19$, $p < .03$). There was no effect for grade ($p > .41$), and no effect for sex ($p > .52$).

1. Digit permutation task. An analysis of covariance of operational level for the permutation task showed a significant effect only for sex ($p < .01$). Female subjects were more systematic in generating a set of permutations than were male subjects. An analysis of covariance for the number of permutations generated also showed a significant effect only for sex ($p < .04$). Female subjects produced significantly more permutations than did male subjects (see Figure 1). A significant interaction between group and sex ($p < .02$) and grade and sex ($p < .02$) was also obtained (see Figure 2). An analysis of simple effects showed that experimental female subjects produced significantly ($p < .01$) more permutations than experimental male subjects, and sixth grade female subjects produced significantly ($p < .001$) more permutations than sixth grade male subjects. An analysis of covariance was also applied to the number of initial marks held constant. There were no significant main effects, but the interaction of grade and sex was significant ($p < .001$).

Table 5

Significant Effects for All Variables

Variable and Effect	M.S.	F	P
Verbal Analogies			
Grade	35.95	8.41	.006
Number of Permutations			
Sex	26.47	4.25	.04
Group by Sex	30.59	4.91	.02
Grade by Sex	31.78	5.10	.02
Initial Marks Constant			
Grade by Sex	499.98	13.04	.001
Permutation			
Sex	1.11	7.11	.01
Feedback Units			
Group	15.85	7.10	.01
Solution Score			
Group	6.61	6.81	.01

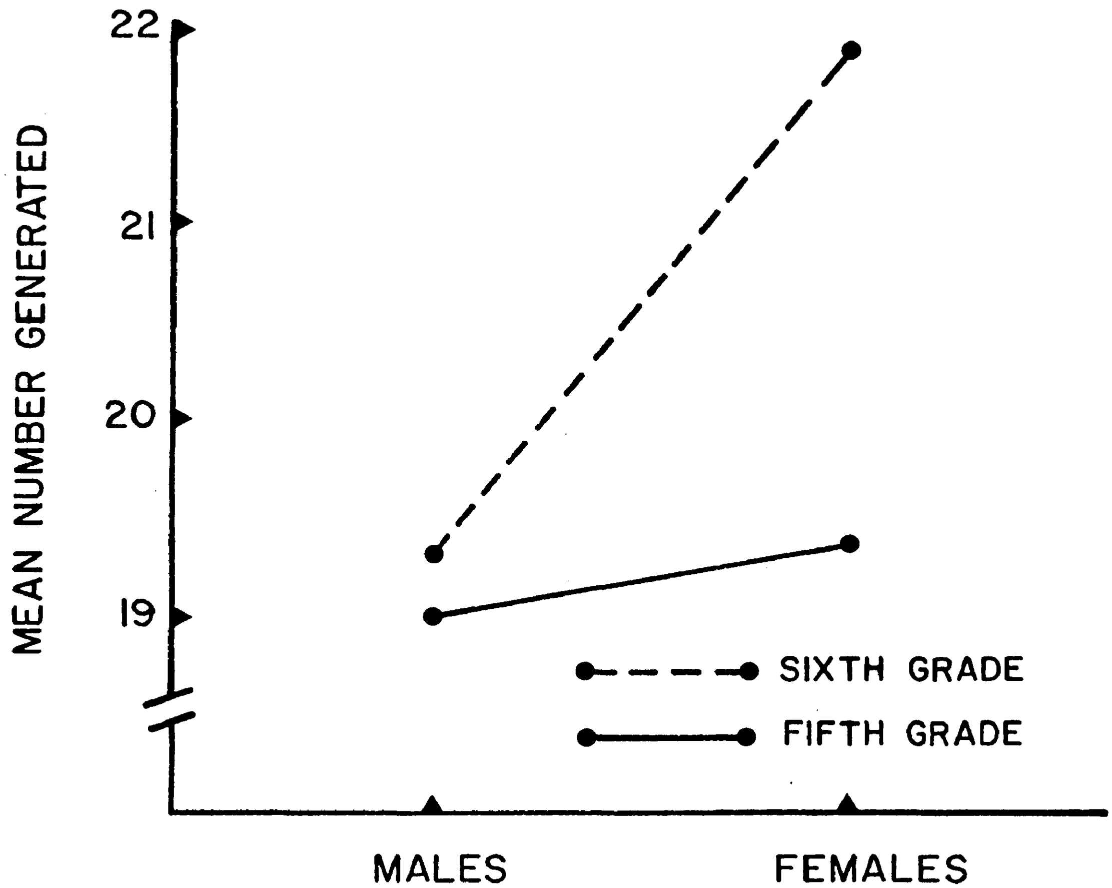

Figure 1. Mean number of permutations generated by grade and by sex.

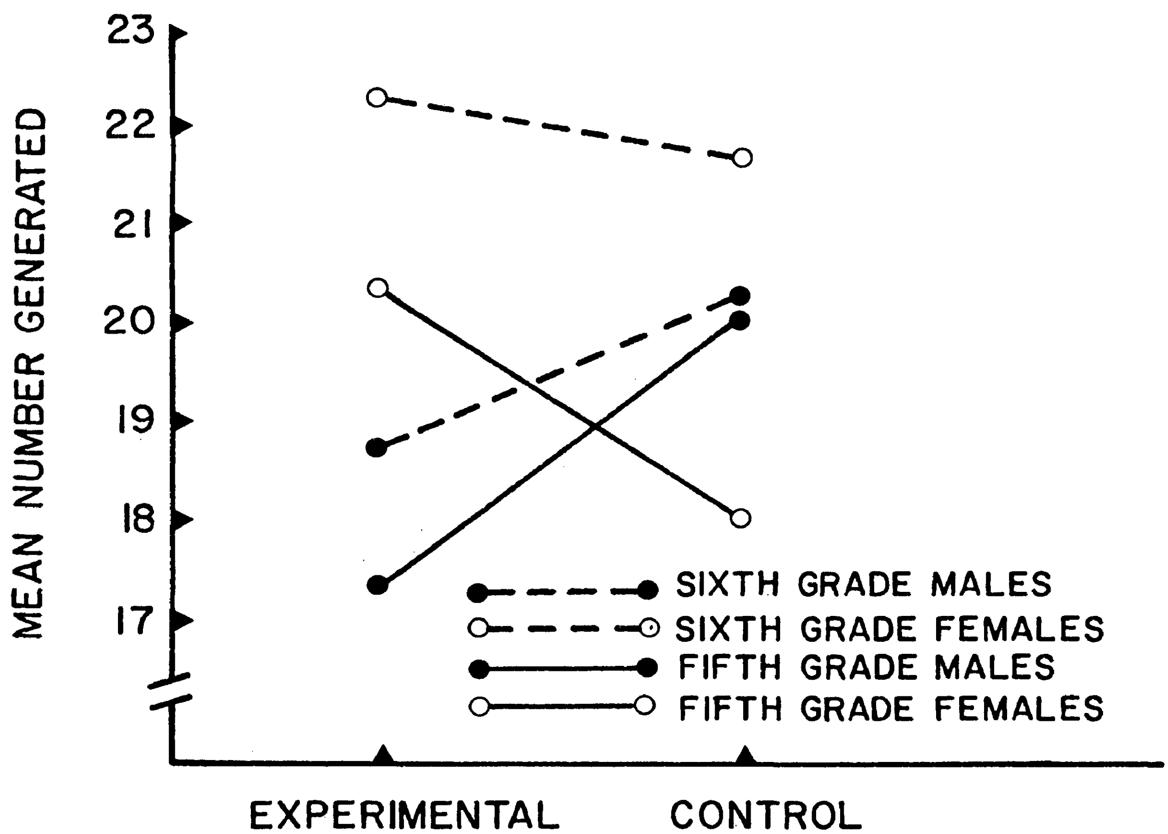

Figure 2. Mean number of permutations generated by subjects and by treatment.

Sixth grade female subjects held significantly more initial marks constant than did fifth grade females (see Figure 3).

2. Chemical combination problem. No significant effects were found for this variable.

3. Pendulum problem. It was earlier hypothesized that field independence would be related to performance on formal reasoning tasks. An analysis of covariance was applied to the pendulum problem with field independence as a predictor variable. No significant effects were found.

4. Group Embedded Figures Test. An analysis of covariance of the posttest GEFT showed no main effect for group, grade or sex. When clearly field dependent and field independent subjects (defined as one S.D. below or above the mean) are isolated, however, (see Table 6) significant differences do appear. In general, the mean score for each variable was higher for field independent subjects than for field dependent subjects.

5. Analogies. An analysis of covariance of the posttest Analogical Reasoning Test score showed no main effect for group, grade or sex. It was earlier hypothesized that a different ability was required to solve the verbal section of the Analogical Reasoning Test. The verbal section was thus investigated as a separate variable. An analysis of covariance of the verbal section of the posttest analogies test showed no effect for group or sex, but there was a significant effect for grade ($p < .006$). A comparison across grades indicate that sixth grade students were significantly more superior in solving the verbal analogies (see Figure 4).

6. Productive thinking problems. An analysis of covariance of each of the four scores on the posttest productive thinking problem

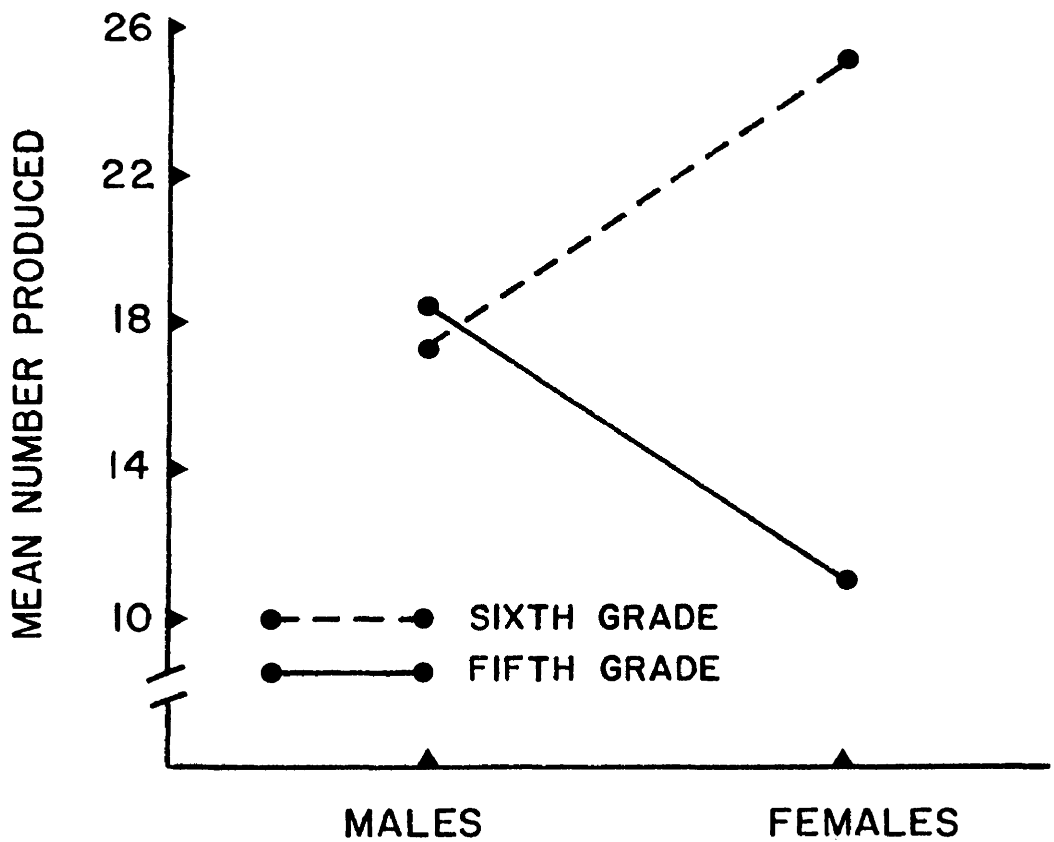

Figure 3. Mean number of initial marks held constant by grade and by sex.

Table 6

ANOVA for Extreme Field Independent-Field Dependent Subjects

Variable	Field Independent X	Field Independent S.D.	Field Dependent X	Field Dependent S.D.	F	P
Pretest						
GEFT	16.65	.79	4.36	1.43	184.67	.001
Analogies	30.94	4.55	20.64	6.31	9.79	.001
Verbal Analogies	13.00	3.14	9.55	1.81	4.95	.01
Permutation	3.18	.64	2.73	.65	2.07	.14
Number of Permutations	21.65	2.15	17.73	4.76	4.15	.02
Initial Marks Constant	21.94	7.05	13.46	8.05	2.97	.06
Chemicals	2.82	.39	2.18	.41	7.10	.002
Number of Clues	2.35	1.22	2.09	1.58	.69	.99
Feedback Units	2.82	.39	2.46	.69	1.52	.23
Number of Ideas	4.12	1.83	3.91	1.51	.15	.99
Solution Score	4.06	1.09	2.55	1.21	5.27	.009
Posttest						
GEFT	16.71	1.86	6.00	2.72	67.52	.001
Analogies	33.65	3.10	25.36	6.49	8.05	.001
Verbal Analogies	14.71	2.29	10.73	1.85	10.52	.001
Permutation	3.47	.72	3.00	.63	3.03	.62
Number of Permutations	22.00	2.42	17.55	4.95	5.91	.005
Initial Marks Constant	25.29	6.50	14.64	8.20	6.24	.004
Chemicals	3.06	.43	2.55	.52	3.02	.06
Number of Clues	1.65	1.22	.73	.65	3.80	.03
Feedback Units	2.82	1.55	3.00	1.55	.23	.99
Number of Ideas	3.94	1.35	3.46	1.37	.34	.99
Solution Score	3.35	1.12	3.00	1.10	.37	.99
Pendulum	3.33	.51	3.17	.47	1.42	.25

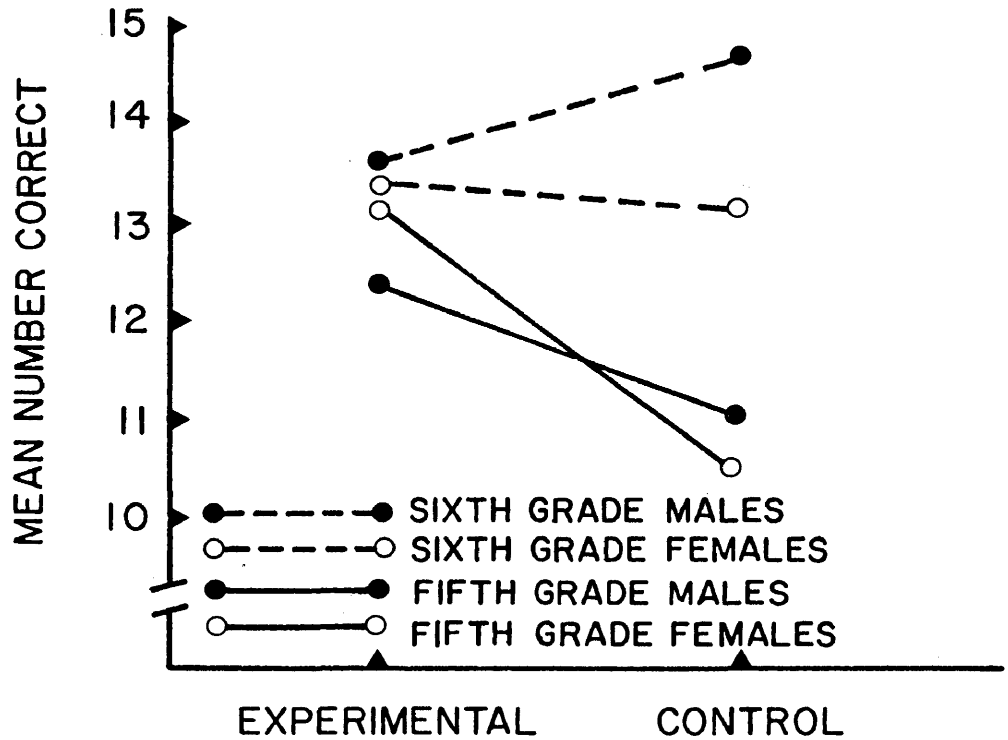

Figure 4. Mean number of correct verbal analogies by subjects and by treatment.

revealed a significant effect of group for the number of correct analytic choices made in the feedback units ($p < .01$) and for the score on the solution scale ($p < .01$). Figure 5 presents the mean number correct for each of the four scores of the posttest productive thinking problem. No other factors or interactions were significant.

Factor Structure of Tests

A Pearson Product Moment correlation matrix showed that the formal operational tasks were low to moderately related with each other (see Table 7). The pretest to posttest correlations for the chemical and permutation problems were significant ($p < .001$). A factor analysis, using the SPSS computer program, was obtained on the posttest measures, IQ, and the two descriptive measures. A varimax rotation required more than 25 iterations and yielded four factors with eigen values greater than one which accounted for 71.4 percent of the variance. Only those factors with eigen values greater than one were rotated. Table 8 presents the 12 variables and their respective factor loadings. Factor 1 seems to tap traditional scholastic achievement: IQ, vocabulary, and comprehension scores. Factor 2 taps performance on the productive thinking problems: number of correct choices made in the units and score on the solution scale. Factor 3 taps analogical reasoning ability: score on the analogies test and the score on the verbal section of the analogies test. Factor 4 taps performance on the formal operational reasoning tasks: pendulum, chemical, and permutation scores.

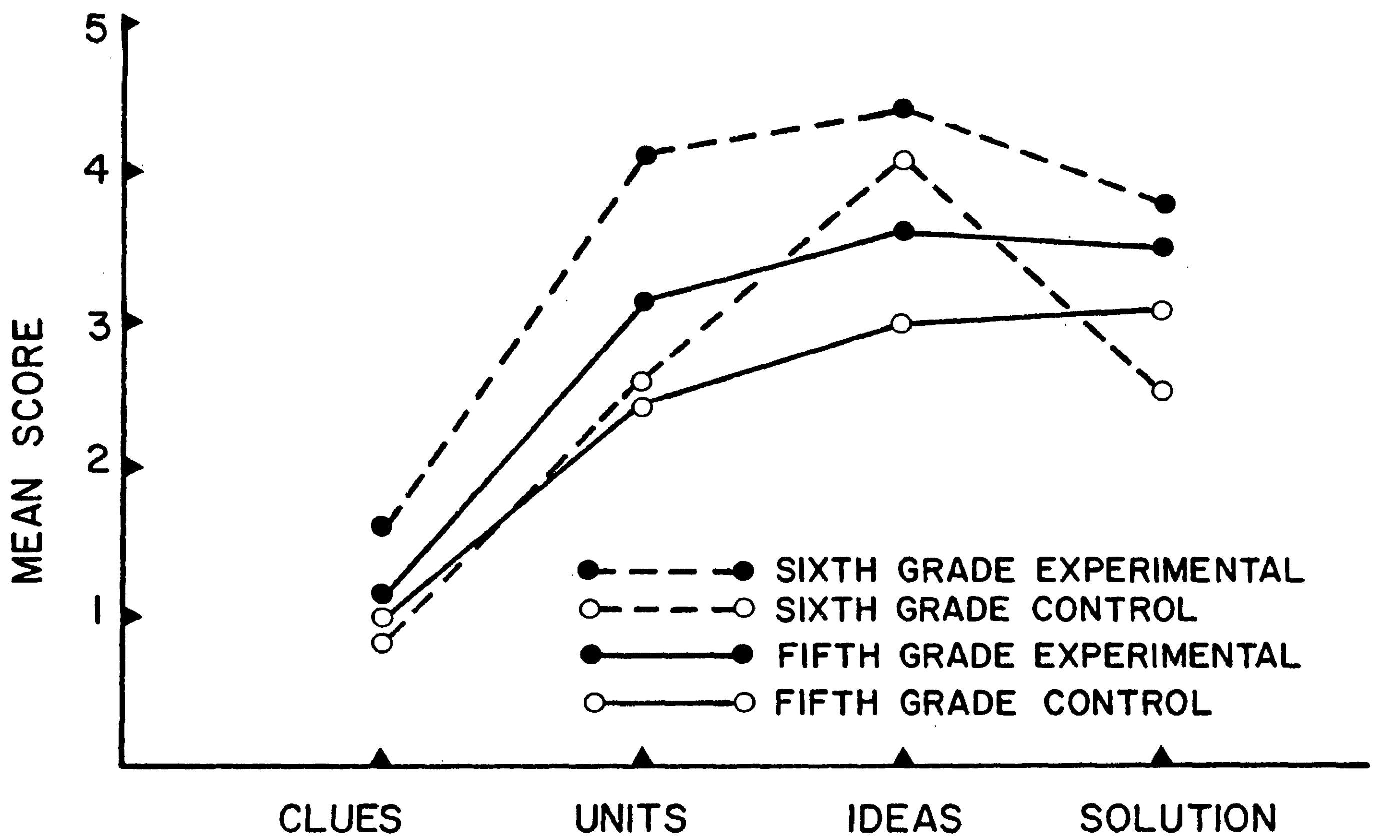

Figure 5. Mean scores for the posttest productive thinking problem.

Table 7

Interrelations for the Formal Operational Tasks

Variable	Pretest Chemical	Posttest Chemical	Pendulum	Pretest Permutation
Posttest Chemical	.69			
Pendulum	.30	.50		
Pretest Permutation	.15	.18	.35	
Posttest Permutation	.18	.29	.34	.82

Table 8

Factor Analysis for the Posttest Variables
and Descriptive Measures

Variable	Factor 1	Factor 2	Factor 3	Factor 4
IQ	.85	-.05	.20	-.02
Vocabulary	.96	.01	.21	.01
Comprehension	.95	.03	.23	.01
Analogies	.24	.29	.80	.26
Verbal Analogies	.27	.21	.74	.28
Pendulum	-.06	.10	-.06	.85
Chemical	-.05	-.05	.13	.60
Permutation	.13	-.08	.29	.44
Number of Clues	-.03	.20	.14	-.09
Number of Ideas	.15	.04	.25	-.02
Feedback Units	.06	.63	.14	-.04
Solution Score	-.04	.97	.05	.15

Teacher Rating Scale

A factor analysis using varimax rotation required 8 iterations and yielded three factors with eigen values greater than one which accounted for 73.9 percent of the variance. Only those factors with eigen values greater than one were rotated. Table 9 presents the PPEF variables and their respective factor loadings. Factor 1 appears to tap a responsiveness or sensitivity to the environment dimension: need for discipline, attention span, parent's attitude, perseverance, intellectual stimulation, initiative, and expected future success. Factor 2 taps a behavorial or performance dimension: verbal ability, participation, activity, degree of need for encouragement, self-confidence, expected future success, and enthusiasm in learning. Factor 3 taps an interactional or social dimension: attractiveness, physical appearance, rapport with peers, adaptability, and self-confidence.

A correlational analysis of the factor scores with the pretest-posttest tasks revealed a highly unstable relationship for the chemical, permutation, and productive thinking problems. However, the pendulum task correlated .27 ($p < .03$) with factor 1. Factor 2 correlated .36 with the GEFT ($p < .01$) and .25 with the analogies test ($p < .04$).

Tables 10 and 11 present data from two separate multiple regression analyses performed to predict the score on the pendulum problem and the analogies test from the personality variables. All variables included in the equation (11 for the pendulum task, 5 for the analogies test) have significant regression coefficients. It appears that the

Table 9

Factor Analysis of PPEF

Variable	Factor 1	Factor 2	Factor 3
Attention Span	.79	.35	.24
Activity and Level of Response	.24	.66	.24
Initiative	.64	.50	.27
Need for Encouragement	.47	.64	.24
Perseverance and Effort	.76	.51	.27
Self-Confidence	.23	.56	.52
Rapport with Peers	.27	.19	.68
Intellectual Stimulation in the Home	.69	.31	.30
Expected Future Success	.54	.55	.36
Enthusiasm and Interest in Learning	.50	.55	.34
Verbal Ability	.35	.73	.03
Discipline	.85	.14	.17
Parent's Attitude Toward Education	.77	.29	.20
Participation in Class	.17	.66	.18
Physical Appearance	.07	.09	.84
Reflectivity-Impulsivity	.49	.45	.30
General Attractiveness	.26	.24	.87
General Adaptation	.44	.38	.64

Table 10

Multiple Regression to Predict the Score on the Pendulum Problem

Variable	Multiple R	F	P
Parent's Attitude Toward Education	.45	10.72	.002
Intellectual Stimulation in the Home	.44	10.24	.003
General Adaptation	.39	7.51	.009
Initiative	.37	7.09	.01
Rapport with Peers	.37	6.73	.01
Attention Span	.36	6.48	.01
Discipline	.36	6.24	.02
Perseverance and Effort	.34	5.45	.02
Expected Future Success	.33	5.23	.03
General Attractiveness	.32	4.89	.03
Physical Appearance	.29	3.91	.05

Table 11

Multiple Regression to Predict the Score on the Analogy Test

Variable	Multiple R	F	P
Expected Future Success	.46	11.37	.002
Reflectivity-Impulsivity	.39	7.93	.007
Verbal Ability	.33	5.21	.03
Attention Span	.30	4.34	.04
Initiative	.30	4.19	.05

two most important variables in predicting the child with a relatively good understanding of the operation of exclusions are: (1) the parent's attitude toward education and (2) the level of intellectual stimulation in the home. The child with a good comprehension of analogical reasoning can best be predicted by: (1) his expected future success and (2) his level of reflectivity-impulsivity. Table 12 is included for later comparison with Cloutier and Goldschmid (1976) and presents the correlation coefficients for the pendulum score and 24 other variables.

Table 12

Correlation Coefficients for the Pendulum Score and 23 other Variables

Variable	r
Intellectual Stimulation in the Home	.52
Expected Future Success	.42
Initiative	.41
Activity and Level of Response	.38
Perseverance and Effort	.37
Parent's Attitude Toward Education	.35
Need for Encouragement	.35
Attention Span	.34
Reflectivity-Impulsivity	.33
General Adaptation	.32
Physical Appearance	.30
Self-Confidence	.30
Rapport with Peers	.30
General Attractiveness	.27
Participation in Class	.25
Enthusiasm and Interest in Learning	.25
Verbal Ability	.23
Comprehension	.20
Vocabulary	.16
Discipline	.14
Sex	.06
IQ	.05
Age	.03

CHAPTER IV

DISCUSSION

The results of the present study indicate that there was a significant transfer of training effect for the productive thinking problem. The superior performance of the experimental subjects suggests that the training program was effective in helping subjects solve this type of problem. There was however no significant difference between the experimental and control groups on the formal operational tasks. The productive thinking problem scores were not correlated with the formal reasoning scores in this study. Saarni (1973) found that Piagetian developmental level significantly predicted problem solving ability only when all eight measures, four for each story, were combined into a single equation (yielding a multivariate F). None of the univariate F's of the eight individual variables significantly differentiated the developmental levels. There is thus only weak evidence that formal operational thinking is required to successfully solve the productive thinking problems. The lack of significant univariate F's may be due to the different content of these two areas. The formal operational tests utilize certain principles of physics and mathematics, whereas the productive thinking problems deal with social skills. This dichotomy may explain the nonexistent correlation between these two tests in the present study, and the weak findings of Saarni. She argues generally, however, that concrete operational children are less able to hypothesize solutions which satisfy the constraints of the problem and transcend the empirical given (suggesting realistic solutions to solve the problem). Formal operational children on the other hand are able to successfully solve problems involving several variables and their interaction. The formal child can construct hypotheses and systematically deduce inferences from them. Saarni also argues that there is a decline in egocentrism with the transition to the subsequent developmental stage which allows the child to decenter the strategies employed to solve the problem. On the basis of this general argument, it appears that the intervention program may have increased the child's flexibility in thinking, his systematicity, and his awareness of inconsistencies in material presented to him by advancing certain substructures of formal thought and consequently decreasing his level of egocentricity.

The training program would not be expected to show change in formal operational problems dealing with physical science and mathematics but rather in applied social problems, since it consisted predominantly of social information processing material. One of the primary goals of the program was to show the child how to systematically evaluate a problem arising in a social context, and to attend to relevant facts and states of the problem in deciding on alternative solutions. The strategies required to solve the productive thinking problems are comparable to the goals of the training program in that they require the child to construct hypotheses, to form logical inferences from them and to systematically evaluate the alternatives involved in problems within a social context. It thus appears that the productive thinking problem requires a type of social information processing strategy similar to that given in the training program. Significant positive changes may not have been found in the GEFT and the analogies test because they require perceptual and conceptual but not social abilities to solve.

Although there was no significant effect of treatment for the verbal analogies, there was an increase ($p < .13$) of number correct for the experimental group. The training program appeared to have a weak effect on the ability to solve verbal analogies (the difference between the pretest and posttest change for the experimental and control groups were from 11.54 to 13.25 for the experimental group, and from 12.14 to 12.66 for the control group). The above increase suggests that the training program contributed to a better understanding of proportional relationships which is a formal operational concept. The fact that sixth grade students were significantly ($p < .006$) more superior in solving the verbal analogies suggests that there is a change in reasoning ability at approximately 11:6 years of age. The present findings thus support the previous research of Goldstein (1962) and Lunzer (1965). The various significant correlations with analogical reasoning suggest that it is a more general form of reasoning (see Table 4). In contrast, the productive thinking problems and formal operations problems appear to be limited to particular content areas and the ability to solve these problems thus requires a more specific form of reasoning.

The results also showed that field independence, productive thinking, and analogies scores correlate low to moderately with the formal reasoning scores. On the other hand, the performance of extreme field independent subjects was superior for all variables except the feedback units in the posttest productive thinking problem. The present findings concerning the relationship between field independence and formal operations contrast with those of Neimark (1975). Neimark found that field independence was correlated significantly (.37 to .46) with the combination and permutation problems. In contrast, the present study found a significant correlation only with the pretest chemicals task. Further research is needed to determine whether this discrepancy is due to the different structure of the tests or due to the different age groups tested. The inconstant correlations between field independence and the Inhelder tasks suggest that the present study finds but weak support for Pascual-Leone's theory.

An examination of the performance on the individual formal operational tests support the existence of décalages in the appearance of formal operational thinking even within a specific content area (see Table 2). The findings show different levels of cognitive ability for the formal operational tasks. Subjects were predominantly transitional for the chemical combination problem and scored predominantly at the early formal stage for both the permutation and pendulum problems. Other evidence for the sequential asynchronous emergence of the formal operations schemata is derived from a comparative analysis of cognitive level for the formal operational tasks. An analysis of the sequence of performance for the posttest formal operations tasks indicate that 42 subjects (81%) have response patterns that support the notion of sequential emergence. The order of difficulty from least to most difficult are: (1) pendulum problem, (2) digit permutation problem, and (3) chemical combination problem. The results support Flavell's (1972) and Martorano's (1974) findings that formal operations emerges sequentially, rather than synchronously as Piaget (Inhelder and Piaget, 1958) has suggested.

On the other hand, the results of the factor analysis support the notion of an underlying factor or structure d'ensemble of formal operational thinking (Lovell and Shields, 1967; Martorano, 1974). This finding supports the notion that the variability in performance on tests related to formal operations is in part a function of the specific content of the tests. The concept of a structure d'ensemble concurrent with the notion of the sequential emergence of formal operations is not an antithetic finding. Martorano (1974) suggests that the development of formal reasoning is a result of the interaction of asynchrony and structure d'ensemble. The asynchronous development of formal thought, in the physical science and mathematical area, an example of Piaget's horizontal décalage at the formal operational stage, only suggests that there exist heterogeneity among children at this particular age. The low to moderate intercorrelations for the formal tasks are consistent with Neimark's (1970) findings, although Bart (1971) reported much higher intercorrelations for three formal operational reasoning tests.

The training program thus appeared to advance certain substructures of formal operations. The results suggest that the transition from concrete to formal operations is not an abrupt change but rather a very gradual process. It appears that an unknown number of formal substructures must develop sufficiently before the transition to the next stage is complete. The results can thus be interpreted to provide partial support for Piaget's equilibration model, although the study does not contain direct evidence for a mechanism of equilibration.

Teacher Rating Scale

The results of the teacher rating scale analysis have produced a more comprehensive understanding of formal operations. In contrast to the finding of Cloutier and Goldschmid (1976) and Flavell (1970), the present study found no relationship between IQ and formal operational level (see Table 12). This finding supports the results of Kaufman (1971) and Stephens, McLaughlin, Miller, and Glass (1972). The present results suggest that IQ measures of intelligence assess different abilities from those measured by the Piagetian tasks. The failure to find a significant relation between the activity variable and formal operational level may be due to the different emphases placed on this variable. The present study stressed physical activity whereas Cloutier and Goldschmid emphasized mental activity.

The results further indicate that the variables Cloutier and Goldschmid (1976) omitted from the scale, those dealing with family, are the best predictors of formal operational ability. It appears that particular variables concerning the influence of the family are important in predicting cognitive abilities, especially the operation of exclusions (see Table 10). The results of the multiple regression do not support Cloutier and Goldschmid's overall characterization of the formal child. The present study found that the formal operational individual, as measured by the pendulum task, is characterized as follows: (1) is reared in an intellectually stimulating home, (2) has parent's that display a positive attitude toward education, (3) seems happy and very well adjusted, (4) usually finds something to occupy himself with when left alone, (5) has very good rapport with his peers,

(6) is often absorbed by the task he is working on, (7) is well disciplined, (8) is persevering, he does not abandon things easily, (9) will succeed better than average in future endeavors, (10) possesses a high level of general attractiveness, and (11) is physically more attractive than the average student. The discrepancy of the profile for the formal student in the present study and that of Cloutier and Goldschmid may be explained by particular situational factors. Cloutier and Goldschmid employed a group paper and pencil test to assess the concept of proportion while the present study used the pendulum task to evaluate the operation of exclusions. Further research is needed to determine whether the incongruity is due to the different formal operational concepts or due to the different structure of the tests.

The child with a good comprehension of analogical reasoning can on the other hand best be characterized as follows: (1) will succeed better than average in future endeavors, (2) is reflective, he thinks seriously before acting, (3) possesses a more highly developed level of verbal ability than the average student, (4) is often absorbed by the task he is working on, and (5) possesses a high level of initiative.

A comparison of predictor variables for formal operational and analogical reasoning (see Tables 10 and 11) indicate that these two abilities are best predicted by different variables. The child with a good understanding of the operation of exclusions can be predicted by factor 1 variables (responsiveness or sensitivity to the environment dimension) and by factor 3 variables (interactional or social dimension). It thus appears that external or environmental (factor 1) variables along with interactional (factor 3) variables are important determinants of cognitive development, as measured by the operation of exclusions. This supports Piaget's (1972) reassessment of formal operations, that the rate of attainment is primarily a result of environmental factors. Analogical reasoning contrasts with formal reasoning in that both external or environmental (factor 1) variables and internal or performance (factor 2) variables are equal predictors of ability. The results suggest that variables controlled by internal determinants are relatively unimportant in the development of formal operations, although they are important in the development of analogical reasoning. The findings that only external abilities are related to formal operations is further evidence that formal operational reasoning is a more limited form of reasoning than is analogical reasoning.

The present study did not control for the Hawthorne effect since Haas (Note 5) found that special treatment alone did not induce increases in performance. The limited number of available subjects and materials also dictated the use of a two group instead of a four group design. The Hawthorne effect is said to be operative when changes in the experimental group are caused by an increase in morale and motivation, rather than being due to the intervention. The author furthermore elected not to control for the effect since it is improbable that special attention alone could produce higher scores on the measures employed in the present study.

Conclusion

The major purpose of the study was to investigate the role of experience in cognitive development. The training program produced significant increments in the thinking and problem solving ability of both fifth and sixth grade students. The study also showed that analogical reasoning is a more general form of reasoning than is formal operational reasoning. It was suggested that formal operations may be manifested differentially in different content areas.

There is clearly a need for further research into: (1) what extent the training generalizes to other kinds of reasoning or to other forms of formal operations, (2) clarifying the role of experience in the development of formal operations, (3) a closer examination of individual differences affecting formal operational development, and (4) establishing the consistency of performance and sequence across different Piagetian tasks. Future training studies should incorporate other measures of individual differences to further elucidate the role of experience in cognitive development.

Reference Notes

1. Siegler, R. S. Utility of interactional strategies in the study of formal operations reasoning. Paper presented at the Society for Research in Child Development convention, Denver, April, 1975.

2. Webb, R. A. Formal operations in very bright 8 to 14 year olds. Paper presented at the Society for Research in Child Development convention, Denver, April, 1975.

3. Lipman, M. Philosophy for children. Unpublished manuscript, Montclair State College, 1974.

4. Bierman, H. A pilot study in the teaching of logic, research conclusions. Unpublished manuscript, Monclair Public Schools, 1973.

5. Haas, H. J. Philosophical thinking in the elementary schools: An evaluation of the educational program Philosophy for Children. Unpublished manuscript, Rutgers University, 1976.

6. Gillespie, M. L. & Langan, J. T. Personal communication, 1975.

References

Barratt, B. B. Training and transfer in combinatorial problem solving: The development of formal reasoning during early adolescence. Developmental Psychology, 1975, 11, 700-704.

Berzonsky, M. D., Weiner, A. S., & Raphael, D. Interdependence of formal reasoning. Developmental Psychology, 1975, 11, 258.

Brainerd, C. J. Training and transfer of transitivity, conservation, and class inclusion of length. Child Development, 1974, 45, 324-334.

Bruner, J. Studies in cognitive growth. New York: Wiley, 1966.

Case, R. Structures and strictures: Some functional limitations on the course of cognitive growth. Cognitive Psychology, 1974, 6, 544-573.

Cloutier, R. & Goldschmid, M. L. Individual differences in the development of formal reasoning. Child Development, 1976, 47, 1097-1102.

Covington, M. V., Crutchfield, R. S., & Davies, L. B. The productive thinking program. Berkeley, California: Brazelton Printing, 1966.

Dulit, E. Adolescent thinking a la Piaget: The formal stage. Journal of Youth and Adolescence, 1972, 1, 281-301.

Fischbein, E., Pampu, I., & Manzat, I. Effects of age and instruction on combinatory ability in children. British Journal of Educational Psychology, 1970, 40, 261-270.

Flavell, J. H. The developmental psychology of Jean Piaget. New York: Van Nostrand Co., 1963.

Flavell, J. H. & Wohlwill, J. F. Formal and functional aspects of cognitive development. In D. Elkind and J. H. Flavell (Eds.), Studies in cognitive development. New York: Oxford University Press, 1969.

Flavell, J. H. Concept development. In P. H. Mussen (Ed.), Carmichael's manual of child psychology (Vol. 1). New York: Wiley, 1970.

Flavell, J. H. An analysis of cognitive developmental sequences. Genetic Psychology Monographs, 1972, 86, 281-347.

Gelman, R. Conservation acquisition: A problem of learning to attend to relevant attributes. Journal of Experimental Child Psychology, 1969, 7, 167-187.

Goldschmid, M. L. The role of experience in the rate and sequence of cognitive development. In D. R. Green, M. P. Ford and G. B. Flamer (Eds.), Measurement and Piaget. New York: The Maple Press Co., 1971.

Goldstein, G. Developmental studies in analogical reasoning. Unpublished doctoral disservation, University of Kansas, 1962.

Goodnow, J. J. A test of milieu effects with some of Piaget's tasks. Psychological Monographs, 1962, 76, 36.

Goodnow, J. J. & Bethon, G. Piaget tasks: The effects of schooling and intelligence. Child Development, 1966, 37, 573-582.

Inhelder, B. & Piaget, J. The growth of logical thinking from childhood to adolescence. New York: Basic Books, 1958.

Jackson, S. The growth of logical thinking in normal and sub-normal children. British Journal of Educational Psychology, 1965, 35, 255-258.

Kaufman, A. S. Piaget and Gesell: A psychometric analysis of tests built from their tasks. Child Development, 1971, 42, 1341-1360.

Kingsley, R. C. & Hall, V. C. Training of conservation through the use of learning sets. Child Development, 1967, 38, 1111-1126.

Kuhn, D. & Angelev, J. An experimental study of the development of formal operational thought. Child Development, 1976, 47, 697-706.

Lipman, M. Harry Stottlemeir's discovery. Institute for the Advancement of Philosophy for Children: Montclair State College, 1974.

Lipman, M. & Sharp, A. Teaching children philosophical thinking. Institute for the Advancement of Philosophy for Children: Montclair State College, 1975.

Lovell, K. A follow-up study of Inhelder and Piaget's "The growth of logical thinking." British Journal of Psychology, 1961, 52, 143-153.

Lovell, K. & Shields, J. B. Some aspects of the study of the gifted child. British Journal of Educational Psychology, 1967, 37, 201-208.

Lunzer, E. A. Problems in formal reasoning in test situations. Monographs of the Society for Research in Child Development, 1965, 30 (2, Serial No. 100).

Martorano, S. C. The development of formal operations thought. Unpublished doctoral dissertation, Rutgers University, 1974.

Neimark, E. D. Longitudinal development of formal operations thought. Genetic Psychology Monographs, 1975, 91, 171-225.

Pascual-Leone, J. A. A mathematical model for transition in Piaget's developmental stages. Acta Psychologica, 1970, 32, 301-345.

Peluffo, N. Culture and cognitive problems. International Journal of Psychology, 1967, 2, 187-198.

Piaget, J. Intellectual evolution from adolescence to adulthood. Human Development, 1972, 15, 1-12.

Ross, R. J., Hubbell, C., Ross, C. G., & Thompson, M. B. The training and transfer of formal thinking tasks in college students. Genetic Psychology Monographs, 1976, 93, 171-187

Saarni, C. I. Piagetian operations and field independence as factors in children's problem solving performance. Child Development, 1973, 44, 338-345.

Siegler, R. S. & Liebert, R. M. Acquisition of formal scientific reasoning by 10 and 13 year olds: Designing a factorial experiment. Developmental Psychology, 1975, 11, 401-402.

Smedslund, J. The acquisition of conservation of substance and weight in children. Scandinavian Journal of Psychology, 1961, 2, 71-84.

Stephens, B., McLaughlin, J. A., Miller, C. K., & Glass, G. C. Factorial structure of selected psychoeducational measures of Piagetian reasoning assessments. Developmental Psychology, 1972, 6(2), 343-348.

Sutherland, A. & Goldschmid, M. L. Negative teacher expectation and IQ change in children with superior intellectual potential. Child Development, 1974, 45, 852-856.

Tomlinson-Keasey, C. Formal operations in females from eleven to fifty-four years of age. Developmental Psychology, 1972, 6, 364.

Wallach, L., Wall, J. A., & Anderson, L. Number conservation: The roles of reversibility, addition-subtraction, and misleading perceptual cues. Child Development, 1967, 38, 425-442.

Wohlwill, J. F. & Lowe, R. C. Experimental analysis of the development of the conservation of number. Child Development, 1962, 33, 153-167.

Yudin, L. W. Formal thought in adolescence as a function of intelligence. Child Development, 1966, 37, 697-708.

APPENDIX A

ANALOGY TEST

An analogy question tests your ability to see a relationship between words and to find the same relationship in the other words.

Example 1. WINTER is to SUMMER as COLD is to WET-HOT-FREEZING.

WINTER and SUMMER have an opposite relationship. COLD and HOT have the same type of relationship (opposite). Therefore, HOT is the correct answer. Please circle the correct answer HOT.

Example 2. CUP is to DRINK as SUPPER-PLATE-WATER is to FORK-SILVER-EAT.

You DRINK from a CUP and EAT from a PLATE. PLATE and EAT are therefore the correct answers. The same relationship exists between DRINK and CUP that exists between EAT and PLATE. Please circle the correct answers EAT PLATE.

Example 3. WOOD is to TABLE as RUBBER-STEEL-LUMBER is to KNIFE-IRON-COAL.

A TABLE is made from WOOD and a KNIFE is made from STEEL. KNIFE and STEEL are therefore the correct answers. Please circle KNIFE STEEL.

Example 4. WHEEL is to CAR as KEY-TIRE-FORD is to FOOD-TYPEWRITER-STOVE.

Example 5.

2	4
8	10
3	5
6	___

For the numerical analogies, fill in the blank with the number that has the same relationship as the other numbers. The correct answer is 8. The 8 is derived by adding 2 to the numbers in the first column.

Example 6. 40, 35, 30, ___, ___, 15

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

VERBAL ANALOGIES

1. HARD is to SOFT as BLACK is to RED-WHITE-GRAY.

2. DRINK is to WATER as EAT is to LUNCH-SUPPER-FOOD.

3. RUNNERS are to SLED as WHEELS are to ROAD-CAR-RACE.

4. PORK is to PIG as BEEF is to STEER-ROAST-STEAK.

5. BRUSH is to PAINT as PEN is to LETTER-WRITE-CANVAS-STAMP.

6. BEACON is to LIGHTHOUSE as INFANT is to TEEN-ADULT-CRY-MOTHER.

7. BICYCLE is to PEDAL as CLOCK is to HAND-WATCH-CALENDAR-SADDLE.

8. DARK is to LIGHT as FLOOR is to CEILING-ROOF-WALL-ROOM.

9. CASH is to NOW as TODAY-CREDIT-BANK is to BUY-MONEY-LATER.

10. JOB is to CHORE as PRISONER-GUARD-WARDEN is to JUDGE-CONVICT-LAWYER.

11. CLUMSY is to GRACEFUL as LIFE-POWER-HUMAN is to BLOOD-STRENGTH-DEATH.

12. LEATHER is to SHOE as SNEAKER-CLAY-SCULPTURE is to BRICK-HARD-MONUMENT.

13. TIRE is to CAR as LEG-FINGER-BRAIN is to GAS-RING-CHAIR.

14. CALENDAR is to YEAR as TIME-CLOCK-NIGHT is to DAY-WEEK-MONTH.

15. SHEEP is to FLOCK as HERD-PACK-SOLDIER-SWARM is to COW-BEE-REGIMENT-WOLF.

WHEN YOU HAVE FINISHED, GO ON TO THE NEXT PAGE

16. FOOT is to MAN as SHOE-HOOF-WOMAN-DONKEY is to HORSE-BLACKSMITH-STABLE-WAGON.

17. MOUNTAIN is to PEAK as VALLEY-TOP-WATER-WAVE is to OCEAN-LAKE-CREST-HIGH.

18. TELEPHONE is to WIRE as RADIO-COPPER-PROGRAM-TUNE is to PROGRAM-WIRELESS-TELEVISION-SONG.

19. RIVER is to BEND as STRAIGHT-WATER-ROAD-SHIP is to TURN-CROOKED-CAR-HIGHWAY.

20. FIRST is to ONE as MINUTE-HOUR-SECOND-DAY is to TWO-TWELVE-SIXTY-NIGHT.

NUMERICAL ANALOGIES

21.	5	3	22.	3	6	23.	8	4
	3	1		1	4		5	1
	7	5		6	9		7	3
	9	___		2	___		9	___
24.	3	6	25.	15	5	26.	4	16
	6	12		24	8		2	8
	8	16		9	3		6	24
	5	___		30	___		7	___
27.	6½	9	28.	3	9	29.	27	18
	8½	11		5	25		34	25
	24	26½		9	81		15	6
	3½	___		8	___		10	___

WHEN YOU ARE FINISHED, GO ON TO THE NEXT PAGE

30.

2	4
7	49
3	9
1	____

31.

8	15
16	23
32	39
64	____

32.

4	32
7	56
12	96
9	____

33.

16	4
36	9
8	2
40	____

34.

4	16
8	64
12	144
6	____

35.

63	5
21	3
77	11
42	____

36. 3, 6, 9, ____, ____, 18.

37. 80, 40, 20, ____, ____, $2\frac{1}{2}$.

38. 4, 12, 36, ____, ____, 972.

39. 7, 28, 112, ____, 1792.

40. 89, 72, 55, ____, ____, 4.

APPENDIX B

SCORING CRITERIA FOR PIAGETIAN TASKS

Chemical

1. Early concrete
   a. subject randomly associates 2 elements at a time
   b. subject tries g with all other elements simultaneously
   c. subject does not use 2 by 2 combinations without prompting
2. Late concrete
   a. subject makes n + n + g combinations spontaneously
   b. subject discovers the effect of element 4
   c. subject is predominantly unsystematic in his combinations
3. Early formal
   a. subject produces some systematic combinations, but is predominantly unsystematic
   b. subject is able to test the effects of elements 2 and 4 when questioned by the experimenter
4. Late formal
   a. subject is predominantly systematic in producing combinations
   b. subject looks for all combinations
   c. subject spontaneously finds the effects of elements 2 and 4

Pendulum

1. Early concrete
   a. subject does not isolate variables
   b. subjects' explanations and experiments contradict each other
2. Late concrete
   a. subject does not isolate variables
   b. isolation of variables occurs accidently
   c. subject lists multiple factors as responsible for the speed of oscillation
3. Early formal
   a. subject isolates and varies different factors, but not consistently
   b. subject does not eliminate all extraneous factors
4. Late formal
   a. subject spontaneously and consistently isolates variables
   b. subject can prove his conclusions

Permutation

1. Early concrete
   a. subject uses no system
   b. subject has repeats
2. Late concrete
   a. subject chains several systems together
3. Early formal
   a. subject uses system that works
   b. subject does not use system to completion
4. Late formal
   a. subject uses system, giving all 24 permutations
   b. subject has no repeats